Investigating a Concentrated Tornado Outbreak in Southeastern Florida Preceding Hurricane Ian's Direct Impact

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Abstract: *Before Hurricane Ian made landfall in southwestern Florida in 2022 as a category 4 storm, a tornado outbreak produced South Florida's average annual amount of tornadoes in less than 24 hours. This study investigated conditions present at the time of the event and in comparison to other cyclones reporting similar behaviors to identify what contributed to this phenomenon. Previous research indicated that tropical cyclones taking a northeastern track while originating from the Gulf of Mexico place South Florida in a favorable sector for tornadic events (Hagemeyer, n.d., pp. 1-2). Additional research suggested the presence of diurnal implications between sea and land surface temperatures and the timing of tropical cyclone tornado outbreaks, similar to Ian's events (Hagemeyer, 1997, p.405). Consequently, storm placement and propagation, temperature differences, latent heat release, wind direction, advection, and divergence all explained the origin of these events.*

Introduction

On the evening of September 27th, 2022, and into September 28th, a total of 14 tornadoes were confirmed by the NHC in FL. The intensity of these events ranged from multiple EF-0s to EF-1s, with a single EF-2 tornado starting in Boca Raton and ending in Delray Beach (peak winds of approx. 125 mph). Hence, two injuries occurred along with the relocation of 30 individuals and $2 million in property damage. The outbreak lasted from about 7 pm to 10 am (EDT) or 00 to 1500 UTC.

Data and Methodology

- Reanalysis data from ECMWF ERA5 was correlated with ASOS data near KMIA, through the variable "average monthly precipitation" in 2022.
- Other variables analyzed from ECMWF ERA5 include latent heat, divergence, sea surface temperature (SST), and both *u* and *v* components of wind.
  - Area studied: 90ºW to 75ºW and 20ºN to 35ºN.
- Investigated reanalysis variables, Skew-T's, and reports from the Mesoscale Discussions provided by the SPC explained the source of energy for supercell production.

Results and Discussion

- R^2 value: 0.873; CORREL function: 0.934
- **SPC Skew-T at 00 UTC/7 pm EDT (Fig. 3 - 4):**
  - Rising air from about 1-15 km; SFC Temp: 81.0ºF
  - Warm air advection: 0.2ºC/km to 4.3ºC/km
  - CAPE: 3285 J/kg; DCAPE: 624 J/kg; CINH: -6 J/kg
  - SARS-Sounding Analogs: 60% TOR; LowRH: 87%
- **SPC MCD Report (Fig. 5):** bulk shear, 35-50 kt
- **Surface latent heat flux (Fig. 6):** - $2e^{06}$ to -$2.6e^{06}$ J/kg
- **Streamlines (Fig. 7):** CC circulation, 0 to 24 kt
- **Sea-surface temperatures (Fig. 7):** 304 K, nearly 88ºF
- **Divergence (Fig. 8):** 0.0001 s^{-1} to 0.00025 s^{-1}

Conclusions

Results identified that energy from significant negative latent heat release and high SST **(Fig. 6-7)** in parts of the Gulf was forced by Hurricane Ian's strong winds and circulation onto South FL, enriching the atmosphere with necessary elements for tornadic events. Findings also demonstrated atmospheric instability **(Fig. 3 - 4)** and enhanced rising air over the east coast **(Fig. 8)** coinciding with the region of the outbreak. Furthermore, patterns suggested in prior research regarding diurnal influences and storm tracks were confirmed. Intended future analysis includes storm-relative helicity and hodographs.

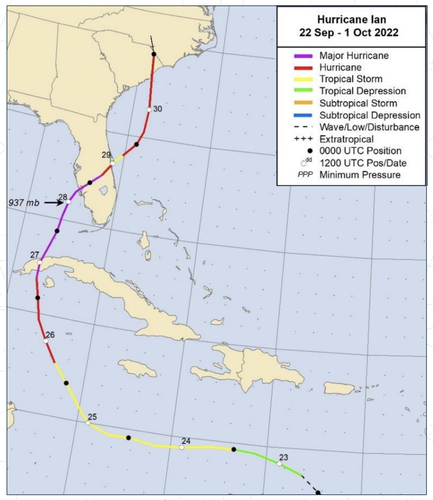


Figure 1: Adapted imagery of Hurricane Ian's track provided by the NHC.

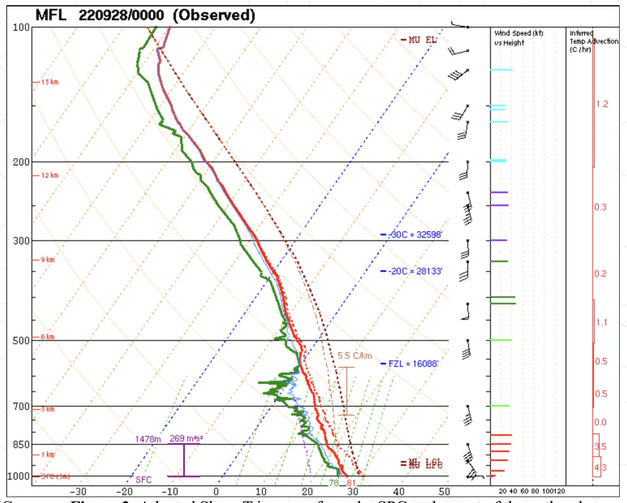


Figure 3: Adapted Skew-T imagery from the SPC at the start of the outbreak.

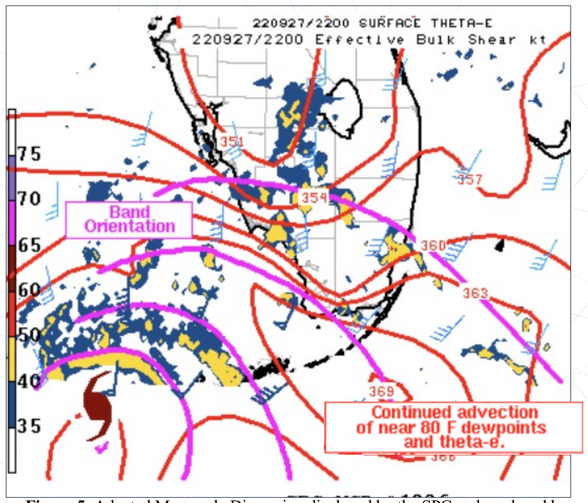


Figure 5: Adapted Mesoscale Discussion displayed by the SPC and produced by meteorologist Jewell (#1836 at 2237 EDT).

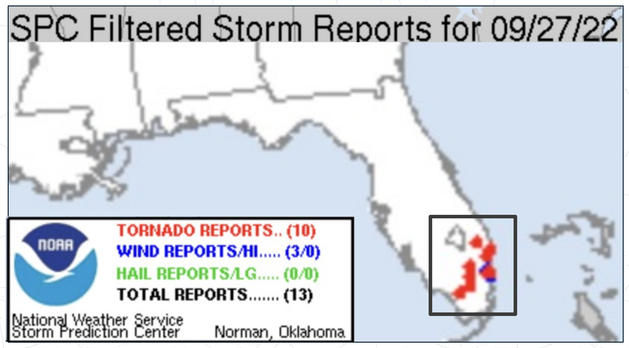


Figure 2: Adapted imagery of the preliminary storm reports produced by the SPC from only Sept. 27.

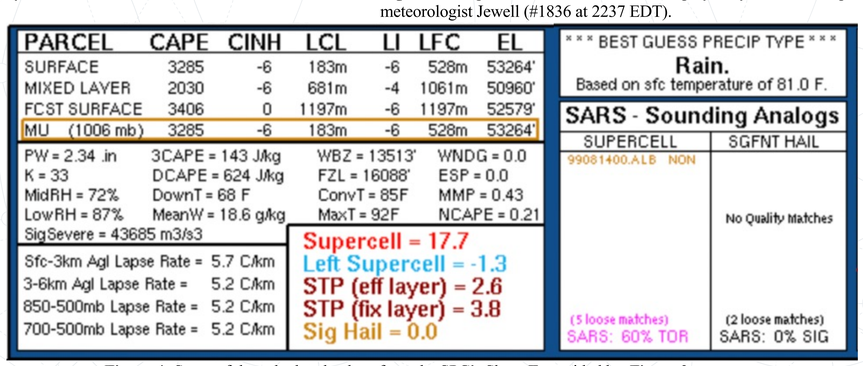


Figure 4: Some of the calculated values from the SPC's Skew-T provided by ***Figure 3.***

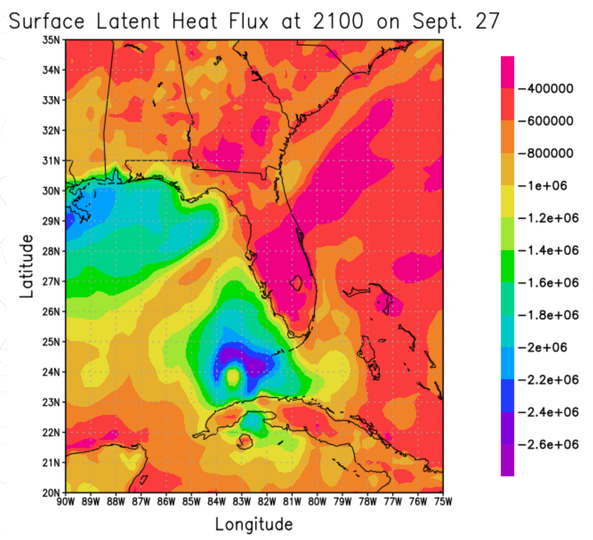


Figure 6: Surface latent heat flux (J/kg) at 2100 EDT is displayed with a range from least negative SLHF (warm colors) to greatest negative SLHF (cooler colors).

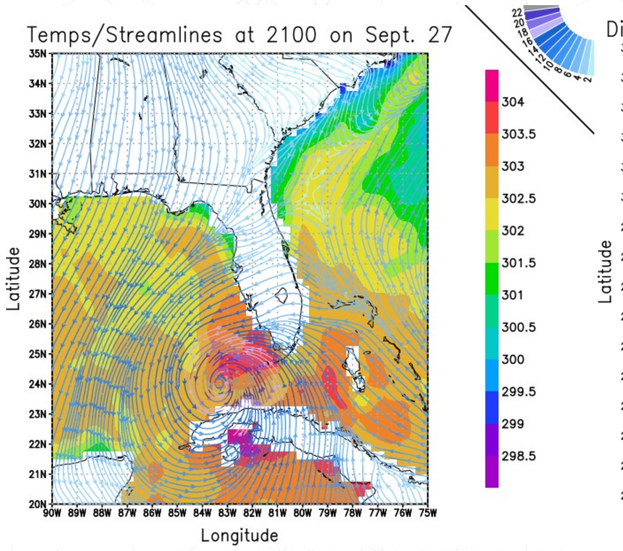


Figure 7: Sea-surface temperatures (K) are displayed, ranging from lower SST (cooler colors) to higher SST (warmer colors). Wind streamlines (kt) are shown on a gradient scale; wind speed increases from light blue to gray. Variables are shown for 2100 EDT.

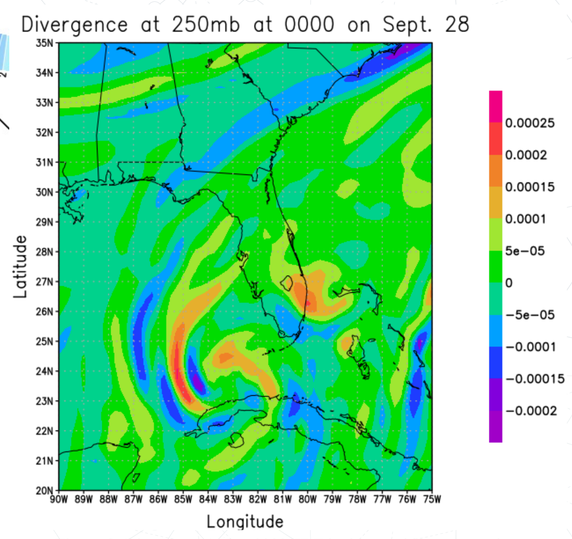


Figure 8: Divergence (s^{-1}) at 0000 EDT is shown with warmer colors indicating rising air and cooler colors suggesting sinking air.

References

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Acknowledgments

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